PERFORMANCE ANALYSIS OF JAMMED HYBRID DS/SFH SYSTEM

Abd El-moneim M. Fouda[1],

ABSTRACT

The conventional Direct sequence DS, and the frequency hopping FH are the common spread spectrum methodologies. The new trend in the spread spectrum communication systems is to use the combined hybrid techniques. The use of a hybrid systems attempt to capitalize upon the advantages of a particular method while avoiding the disadvantages. The paper presents general closed form of the system bit error rate BER assuming noncoherent hybrid DS/SFH employing M-ary frequency shift keying MFSK over Rician fading channel. Moreover; the effect of partial band jamming PBJ on the system performance will be analyzed. Two performance measures are considered; the average BER and system capacity (number of users utilize the system) against SNR for the hybrid DS/SFH is presented. The hybrid DS/SFH performance analysis will be investigated with and without BPJ effect. Moreover; the effect of the rice factor in the system performance will be investigated.

KEYWORDS: Spread Spectrum, DS, FH, Rician Fading, Hybrid, PBJ.

1. INTRODUCTION

In the recent years, the development of communication technologies facilitates the life, and this implies to the tremendous increase of the number of users sharing the same communication channels. The bad effect of the multiuser that sharing the same communication channel is that it may cause a serious problem in the overall system performance and the error rate will increase. Spread spectrum multiple access SSMA one of the multiple-access capabilities has been proven great advantages to overcome such problem. In addition to the SSMA techniques simultaneously provide other desirable qualities including considerable effectiveness in combating various types of intentional interference (jamming) or nonintentional interference.

The two most common spread spectrum techniques are DS, and the FH are the common spread spectrum methodologies. The new trend in the spread spectrum communication systems is to use the combined hybrid techniques;. The most commonly used forms of SSMA are direct-sequence SSMA (DS/SSMA), in which a high-rate code (termed a signature sequence) is used together with the data signal to phase modulate the carrier signal. On the other

1 Modern Academy for Eng. and Technology, Cairo-Egypt. Fouda_1964@yahoo.com"

hand; frequency-hopped SSMA (FH/SSMA), in which a frequency-hopping pattern is used to control a frequency-synthesized carrier signal onto which data are frequency modulated.

Nowadays, the new trend is the hybrid SSMA; there are many hybrid combinations including: DS/FH hybrid system, direct sequence /time hopping hybrid system, frequency hopping /time hopping hybrid system, and the over all combination DS/FH/time hopping hybrid system. we are interested on the DS/FH hybrid system. A disadvantage of hybrid systems is the increased complexity of their transmitters and receivers. From the literature survey it is noted that many researches in the past few years have been investigated the multiple-access capability of DS/SS (e.g., [1]-[2]) and FH/SS (e.g., [3]-[4]) systems have been thoroughly also investigated, hybrid DSFH/SSMA systems have not received sufficient attention.

Throughout this paper we are concerned with the performance of hybrid DS/SFH -SSMA employing the M-ary frequency shift keying (MFSK) systems; where during transmission part the original data is first direct sequence modulated and then frequency-hopped according to a specific frequency-hopping pattern. The considered system is operating through the Rician fading channel that may be encountered in land mobile communication systems, moreover the intentional interference (jamming) will be taken into consideration. There are different types of jamming , the paper assumes the so called partial band jamming PBJ. The performance measure is the average probability of error BER. Besides, the multiple-access capability, or the number of users that the system can deal with will be taken as measurement parameters. The paper is organized as; in section 2; the system model of the Hybrid DS/SFH-MFSK assuming the Rician fading as well as the PBJ is introduced. While in section 3; we develop to introduce to the analysis of the hybrid DS/SFH over the fading channel, the jamming effect is then subjected to the channel. In section 4; a numerical results are presented, then the final conclusion about the paper is provided.

2. SYSTEM MODEL

In this section the effect of Rician fading channel together with partial band jamming signal on the performance of HYBRID DS/SFH –MFSK system will be presented, it is shown in Fig. 1. We will introduce briefly to the system model, jamming model, and channel model. Then, we develop to introduce the system performance and evaluation at the different channel conditions including the Rician channel as well as the channel is corrupted with partial band jamming PBJ.

From the point of view of the hybrid DS/FH system model assuming asynchronous hybrid SFH/DS SSMA system with noncoherent reception of type operating through Rician fading channel corrupted with PBJ, and employing MFSK modulation techniques will be examined. Assume we have K number of active users, so the transmitted signal of the K^{th} user is given as :

$$S_k(t) = \sqrt{2P}\ a_k(t)\ b_k(t) \cos(\omega_c t + \omega_k(t) + \theta_k + \alpha_k(t)) \qquad (1)$$

The receiver model include the signal corrupted with noise, it will be frequency dehopped, then demodulation process is accomplished which considered as a non coherent demodulation process. And then the DS despreader is introduced. The form of the received signal for the hybrid system is given as:

$$r(t) = \sum y_k(t - \tau_k) + n(t) + j(t) \qquad (2)$$

where n(t) and j(t) are the system noise and jamming noise respectively, Thus the corresponding received signal model as:

$$r(t)=\sqrt{2P}\,\gamma_f b_k(t-\tau_\kappa)a_k(t-\tau_\kappa)\cos\{2\pi(f_c+f_{hk}(t-\tau_\kappa))t+\theta_\kappa(t-\tau_\kappa)+\alpha_\kappa(t-\tau_\kappa)\}+j(t)+n(t) \qquad (3)$$

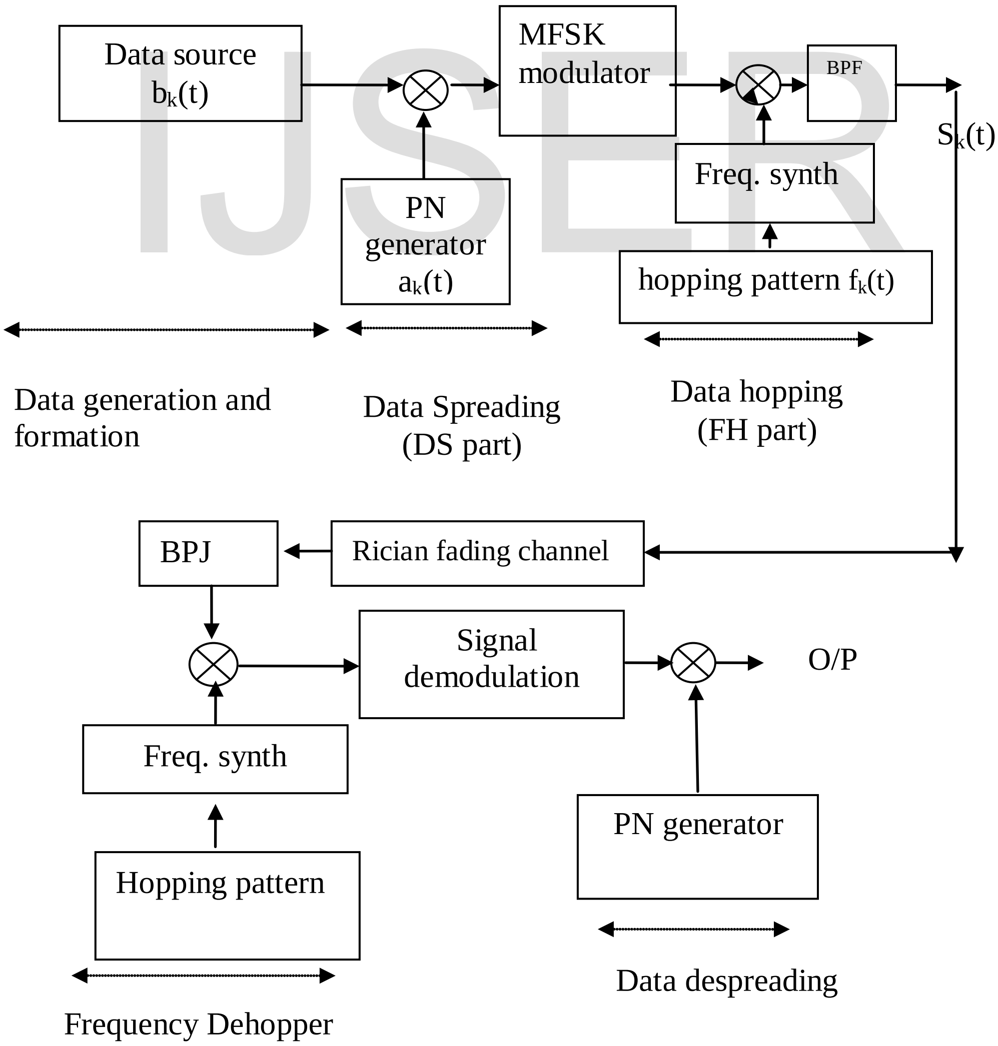

Fig. 1. General block diagram of the Hybrid DS/SFH with PBJ operating through Rician fading channel.

Where P is the average transmitted signal power, and $f_c=2\pi\ \omega_c$ is the carrier frequency common for all users, while $\omega_k(t)$ is the random hopping pattern, it's a first order stationary Markov process, and is derived from a set of q frequencies which is not necessary equally spaced with minimum spacing ω. And $b_k(t)$ is the data bits sequence generated by user k, with the information bit rate $R_b=1/T_b$, where T_b is the information bit duration. random signature sequence with rate $R_c=1/T_c$. Also, θ_k is the random phase introduced by the k^{th} modulator spreader and $\alpha_k(t)$ is the random phase introduced by the k^{th} user frequency hopper.

Moreover from the point of view of the receiver section of the hybrid DS/SFH system. n(t) is the noise term due to background AWGN. It is a Gaussian process with zero mean and double-side power spectral density $N_o/2$. and γ_f is the factor that represent the fading transmission coefficient , it will cause a degradation for the received signal according to the assumed fading type. Due to our assumption that the channel of Rician fading type, then the signal passing through the Rician fading channel will emerge as a composite of a specular component and a multi-path portion. The channel for each hop is modeled as independent frequency nonselective, slowly fading Rician process. This type of Rician fading has been found to occur in practically in many situations including mobile satellite channel, and through the indoor and urban microcellular environment. As a result the envelope (r) of the received signal affected by Rician channel can be rewritten for remembering as [5]:

$$p(r) = \frac{r}{N_0 + \alpha} \exp\left[-\frac{r^2 + u^2}{2(N_0 + \alpha)} \right] . I_0\left(\frac{ru}{N_0 + \alpha} \right) \tag{4}$$

Where N_0 is the thermal noise power, α is the average power of the multi-path portion, u is the amplitude of the specular component and, $I_0(.)$ is the modified Bessel function of first kind and zero order.

Form the point of view of the jammer model, the PBJ intentional interference part $j(t)$ which may be due to a partial band noise jammer, or some unintended narrow band interference. The interference is modeled as additive Gaussian noise and is assumed to be present in a fraction ρ of the total band width [6]. The total power will be distributed through a certain band ρ of the total spread band. If $N_j/2$ is the average power spectral density of interference over the entire spread bandwidth, then $\rho^{-1}\ Nj/2$ will be the power spectral density of the partial-band interference when it is present. In addition to the PBJ, it is assumed that thermal noise and other wide band interference, which is modeled as AWGN with power spectral density of $N_0/2$, corrupt the signal. Thus, the power spectral density PSD of the total noise is $\rho^{-1} N_j/2 + N_0/2$ when interference is present, and it is $N_0/2$ otherwise.

In the BPJ, The transmitted signal may be affected by the jamming signal or not. When the signal is jammed it will be with probability ρ, and in the case when it is not jammed it will be with probability 1-ρ. Then the final BER can be expressed as a combination form of the two terms as follows:

$$P_b = \rho\, P_{b1} - (1-\rho).\, P_{b2} \qquad (5)$$

where P_{b1} and P_{b2} represent the BER when PBJ affects on the transmitted signal or not respectively.

3. PERFORMANCE ANALYSIS

In this section the effect of multiple access interference (MAI) together with intentional partial band jamming (PBJ) on the performance of hybrid DS/SFH-MFSK system will be investigated, it is expected that the system performance will be degraded

First we will start the analysis with non-coherent asynchronous hybrid DS/SFH SSMA system with random signature sequences and hopping patterns, the general error probability of such system is given as [6]:

$$P_{hyp} = \sum_{k_f=0}^{K-1} \sum_{k_p=0}^{K-1-k_f} p_h(k_f, k_p)\, p_{efad}(k_f, k_p) \qquad (6)$$

The first term of Eq. 6 is $p_h(k_f, k_p)$ denotes the probability of the occurrence of k_f full hits and k_p partial hits from the other K-1 users, this parameter can be expressed as:

$$p_h(k_f, k_p) = \binom{(K-1)L}{k_f} \binom{(K-1)L - k_f}{k_p} p_f^{k_f}\; p_p^{kp}\, (1 - p_f - p_p)^{(K-1-k_f-k_p)L} \qquad (7)$$

where K is the total active users in the system. The partial hits probability from other users; given as $P_p = 2/(N_b.q)$, while the full hits probability from other users can be expressed as following $p_f = (1- 1/ N_b)\, /q$, the parameter L represents the number of multipath fading, N_b is the number of data bits transmitted per frequency hop, and q is the number of hopping frequencies

ISSN 2229-5518

The second term of Eq. 6 is $p_{efad}(k_f, k_p)$ denotes the conditional error probability of the system given that k_f full hits and k_p partial hits occurred over the assumed fading channel. The expression of $p_{efad}(k_f, k_p)$ conditional bit error probability is given as [6]:

$$p_{efad}(k_f, k_p) = 0.5\, E\,[\exp(-0.5\,\gamma\, A^2_{i,l})] \tag{8}$$

Since $A^2_{i,l}$ is Rician distributed it is distributed statistically as non-central chi-square random variable and its characteristic function is derived as [6]:

$$E\left[\exp\left(\frac{-\gamma}{2} A_{i,l}^2\right)\right] = \frac{1}{1+\gamma\sigma_\varepsilon^2}\exp\left[\frac{-\gamma\, m_\varepsilon^2}{2(1+\gamma\,\sigma_\varepsilon^2)}\right] \tag{9}$$

Thus we have:

$$p_{efad}(k_f, k_p) = \frac{0.5}{1+\gamma\sigma_\varepsilon^2}\exp\left[\frac{-\gamma\, m_\varepsilon^2}{2(1+\gamma\,\sigma_\varepsilon^2)}\right] \tag{10}$$

Where γ is the average desired signal to the sum of the multipath interference, multiple access interference and the channel noise ratio it is given for the MFSK as [6]:

$$\gamma = \frac{-m}{2(m+1)}\left[\left(\frac{2E_b \log_2 M}{N_0}\right)^{-1} + \frac{(k_f + 0.5k_p)L}{3M.N\log_2 M}\right]^{-1} \tag{11}$$

Where M is the modulation order, now substituting with the expression of γ into Eq.10 to get the following equation:

$$p_{efad}(k_f, k_p) = \left[\frac{0.5}{1+\sigma_\varepsilon^2\,\frac{-m}{2(m+1)}\left[\left(\frac{2E_b \log_2 M}{N_0}\right)^{-1} + \frac{(k_f + 0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right]. \\ \left[\exp\left(\frac{\frac{-m_\varepsilon^2 .\, m}{2(m+1)}\left[\left(\frac{2E_b \log_2 M}{N_0}\right)^{-1} + \frac{(k_f + 0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}{2+2\,\frac{-\sigma_\varepsilon^2 .\, m}{2(m+1)}\left[\left(\frac{2E_b \log_2 M}{N_0}\right)^{-1} + \frac{(k_f + 0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right)\right] \tag{12}$$

where m is the number of bits in the symbol, and N is the number of code bits in each data bit (gain of the DS part). The two parameters m_ε and σ^2_ε represent the mean and the variance of the non-central chi-square distributed random variable $A^2_{i,l}$ and they are respectively given as:

$$m_\varepsilon = \varepsilon/(1+\varepsilon) \quad (13)$$

$$\sigma^2_\varepsilon = 1/(2+2\varepsilon) \quad (14)$$

where ε is the Rician fading factor it is ranged form 6-12 dB for the Rician distribution fading channel, and E_b/N_o is the average signal to noise ratio.

Now using the different expression of $p_{efad}(k_f,k_p)$, $p_h(k_f,k_p)$, p_f, and p_p and substitute into the general form of the BER equation P_{hyp} then we get the final closed form of the noncoherent hybrid DS/SFH SSMA asynchronous system employing MFSK and operating through Rician channel without any jamming effect given as:

$$P_{hypRicnj} = \sum_{k_f}^{K-1} \sum_{k_p}^{K-1-k_f} \sum_{m=1}^{M-1} \binom{M-1}{m} \frac{(-1)^{m+1}}{m+1} .. \left[\frac{0.5}{1+\sigma^2_\varepsilon \frac{-m}{2(m+1)} \left[\left(\frac{2E_b \log_2 M}{N_0} \right)^{-1} + \frac{(k_f + 0.5k_p)L}{3M.N \log_2 M} \right]^{-1}} \right]$$

$$\left[\exp\left(\frac{\frac{-m^2_\varepsilon . m}{2(m+1)} \left[\left(\frac{2E_b \log_2 M}{N_0} \right)^{-1} + \frac{(k_f + 0.5k_p)L}{3M.N \log_2 M} \right]^{-1}}{2+2\frac{-\sigma^2_\varepsilon . m}{2(m+1)} \left[\left(\frac{2E_b \log_2 M}{N_0} \right)^{-1} + \frac{(k_f + 0.5k_p)L}{3M.N \log_2 M} \right]^{-1}} \right) \right] .$$

$$\binom{(K-1)L}{k_f} \binom{(K-1)L - k_f}{k_p} p_f^{k_f} \; p_p^{kp} (1 - p_f - p_p)^{(K-1-k_f-k_p)L} \quad (15)$$

Then after rearrangement process and substituting with P_f and P_p we get the following formula assuming no jamming effect:

$$P_{hypRicnj}=\sum_{k_f}^{K-1}\sum_{k_p}^{K-1-k_f}\sum_{m=1}^{M-1}\binom{M-1}{m}\binom{(K-1)L}{k_f}\binom{(K-1-k_f)L}{k_p}\frac{(-1)^{m+1}}{m+1}.\left(\frac{2}{N_b q}\right)^{k_p}\left(\frac{1-N_b^{-1}}{q}\right)^{kf}$$
$$\left(1-\left(\frac{2}{N_b q}\right)-\left(\frac{1-N_b^{-1}}{q}\right)\right)^{(K-1-k_f-k_p)L}$$

$$.\left[\frac{0.5}{1+\sigma_\varepsilon^2\frac{-m}{2(m+1)}\left[\left(\frac{2E_b\log_2 M}{N_0}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right]$$
$$\left[\exp\left(\frac{\frac{-m_\varepsilon^2.\,m}{2(m+1)}\left[\left(\frac{2E_b\log_2 M}{N_0}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}{2+2\frac{-\sigma_\varepsilon^2.\,m}{2(m+1)}\left[\left(\frac{2E_b\log_2 M}{N_0}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right)\right] \quad (16)$$

Now, if we extend the derivation to include the effect of the PBJ, then the parameter N_0 will not exist alone, this parameter will be mixed with the jamming density N_j multiplied by the ratio by which the channel is jammed; thus in the case of PBJ jamming we will have $N_0+\rho^{-1}N_j$

First we will start as before in the above analysis with non-coherent asynchronous hybrid DS/SFH SSMA system with random signature sequences and hopping patterns, the general error probability of such system is similar to that of the previous section and rewritten as:

$$P_{hybRicj}=\sum_{k_f}^{K-1}\sum_{k_p}^{K-1-k_f} p_h(k_f,k_p)\,p_{ej}(k_f,k_p) \quad (17)$$

Where $p_h(k_f,k_p)$ as previously mentioned in Eq.7, now to complete the analysis and to get a general closed form for the hybrid DS/SFH employing MFSK under the effect of PBJ condition over Rician fading channel we must get an expression of $p_{ej}(k_f,k_p)$ which represent the conditional error probability of the system given that k_f full hits and k_p partial hits occurred, according to such conditional probability can be expressed as:

$$p_{ej}(k_f,k_p)=\sum_{m=1}^{M-1}\binom{M-1}{m}\frac{(-1)^{m+1}}{m+1}.$$

$$.\left[\frac{0.5}{1+\sigma_{\varepsilon}^{2}\,\frac{-m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right]$$

$$\left[\exp\left(\frac{\frac{-m_{\varepsilon}^{2}.\,m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}{2+2\frac{-\sigma_{\varepsilon}^{2}.\,m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right)\right] \qquad (18)$$

Now using the different expression of $p_{ej}(k_f,k_p)$ from the above equation and $p_h(k_f,k_p)$, p_f, and p_p from the previous section, substitute into the form above of Eq. 17. then we get the following:

$$P_{hybRicj}=\sum_{k_f}^{K-1}\sum_{k_p}^{K-1-k_f}\sum_{m=1}^{M-1}\binom{M-1}{m}\binom{(K-1)L}{k_f}\binom{(K-1-k_f)L}{k_p}\frac{(-1)^{m+1}}{m+1}.\left(\frac{2}{N_b q}\right)^{k_p}\left(\frac{1-N_b^{-1}}{q}\right)^{kf}$$

$$\left(1-\left(\frac{2}{N_b q}\right)-\left(\frac{1-N_b^{-1}}{q}\right)\right)^{(K-1-k_f-k_p)L}$$

$$.\left[\frac{0.5}{1+\sigma_{\varepsilon}^{2}\,\frac{-m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right]$$

$$\left[\exp\left(\frac{\frac{-m_{\varepsilon}^{2}.\,m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}{2+2\frac{-\sigma_{\varepsilon}^{2}.\,m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right)\right] \qquad (19)$$

Now the effect of PBJ leads to the probability that a hop is jammed is ρ, and the probability that it is not jammed is (1-ρ). Thus the total overall probability will be:

$$P_{hypRicPBJ} = (1-\rho).\ P_{hybRicnj} + \rho.\ P_{hybRicj} \qquad (20)$$

substituting with $P_{hybRicnj}$ of the previous section BER expression at Rician fading with no jamming; while $P_{hybRicj}$ means BER expression at Rician fading channel with jamming of type PBJ, then we get the final closed form expression of the noncoherent asynchronous hybrid DS/SFH-MFSK SSMA under the PBJ effect operating through Rician fading channel as:

$$
\begin{aligned}
P_{hybRicPBJ} &= (1-\rho).\Bigg(\sum_{k_f}^{K-1}\sum_{k_p}^{K-1-k_f}\sum_{m=1}^{M-1}\binom{M-1}{m}\binom{(K-1)L}{k_f}\binom{(K-1-k_f)L}{k_p}\frac{(-1)^{m+1}}{m+1}.\left(\frac{2}{N_b q}\right)^{k_p}\left(\frac{1-N_b^{-1}}{q}\right)^{kf} \\
&\left(1-\left(\frac{2}{N_b}\right)-\left(\frac{1-N_b^{-1}}{q}\right)\right)^{(K-1-k_f-k_p)L} \\
&.\left[\frac{0.5}{1+\sigma_\varepsilon^2\frac{-m}{2(m+1)}\left[\left(\frac{2E_b\log_2 M}{N_0}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right] \\
&\left[\exp\left(\frac{\frac{-m_\varepsilon^2.\,m}{2(m+1)}\left[\left(\frac{2E_b\log_2 M}{N_0}\right)^{-1}+\frac{(k_f+0.5k_p)}{3M.N\log_2 M}\right]^{-1}}{2+2\frac{-\sigma_\varepsilon^2.\,m}{2(m+1)}\left[\left(\frac{2E_b\log_2 M}{N_0}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right)\right] \\
&+\rho.\sum_{k_f}^{K-1}\sum_{k_p}^{K-1-k_f}\sum_{m=1}^{M-1}\binom{M-1}{m}\binom{K-1}{k_f}\binom{K-1-k_f}{k_p}\frac{(-1)^{m+1}}{m+1}.\left(\frac{2}{N_b q}\right)^{k_p}\left(\frac{1-N_b^{-1}}{q}\right)^{kf}. \\
&\left(1-\left(\frac{2}{N_b q}\right)-\left(\frac{1-N_b^{-1}}{q}\right)\right)^{(K-1-k_f-k_p)L} \\
&.\left[\frac{0.5}{1+\sigma_\varepsilon^2\frac{-m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)L}{3M.N\log_2 M}\right]^{-1}}\right] \\
&\left[\exp\left(\frac{\frac{-m_\varepsilon^2.\,m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}\,SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)}{3M.N\log_2 M}\right]^{-1}}{2+2\frac{-\sigma_\varepsilon^2.\,m}{2(m+1)}\left[\left(\frac{2\log_2 M}{SNR^{-1}+\rho^{-1}SJR^{-1}}\right)^{-1}+\frac{(k_f+0.5k_p)}{3M.N\log_2 M}\right]^{-1}}\right)\right]\Bigg) \qquad (21)
\end{aligned}
$$

4. NUMERICAL RESULTS

Now, we develop to use MATLAB software to analyze and study the performance of the hybrid DS/SFH-MFSK operating through the Rician fading channel only. The performance measures are the SNR and the system capacity which is labeled as K that identify the number of users utilizing the channel.

The plotting in figure2 represents the BER against SNR performance of the hybrid DS/SFH-MFSK over the Rician fading. The calculations are achieved assuming M=4, the number of frequency hops q=100, the number of chips per bits N=31, the number of bits per hops N_b=10 bits/hop, the number of fading paths L=4, and the SNR is ranged from 0 to 30 dB. Different values of the rice fading factor are assumed ε=6, 10 and 12 dB. It is found from the plot that the BER is affected by the value of the Rice factor, the increase the value of the rice factors means the increase the value of the specular component that means L.O.S components dominate the other components, thus the system performance is better.

The plotting in figure3 represents the BER against system capacity performance of the hybrid DS/SFH-MFSK over the Rician fading. The calculations are achieved assuming M=4, the number of frequency hops q=100, the number of chips per bits N=31, the number of bits per hops N_b=10 bits/hop, the number of fading paths L=4, and the SNR is fixed at value equal to 10 dB. Different values of the rice fading factor are assumed ε=6, 10 and 12 dB. It is found from the plot that the system capacity is affected by the value of the Rice factor, for the same number of users the increase the value of the rice factors, implies the system capacity is better since the BER is enhanced with the increase of the rice factor.

The plot in figure 4 illustrates the performance of the hybrid DS/SFH-MFSK with and without the effect of PBJ and operating through Rician fading channel. The calculations are achieved assuming the ratio of the fraction band to be jammed ρ=0.5, the number of multipath fading components L=4, the rice fading factor ε=12 dB, total number of active users K will be taken as a performance measure that will identify the maximum number of users utilizing the channel or briefly indicate to the overall system capacity, the number of frequency hops q=100, the number of chips per bits N=31, the number of bits per hops N_b=10 bits/hop. It is noted from the figure that the over all system performance will be degraded when the PBJ is exist compared to the case with no jamming.

5. CONCLUSIONS

In this paper, we have been presented the performance analysis of the noncoherent hybrid DS/SFH-SSMA employing the MFSK under the effect of the Rician fading channel conditions, as well as under the effect of partial band jamming. A closed form expression that represents the BER of such hybrid system was derived in the case of Rician fading channel with and without the effect of PBJ. The bit error rate against the SNR assuming different values of rice factors were developed, also the system capacity were used as a performance measure. It was concluded that the BER and the system capacity were affected by the value of the Rice factor, the increase the value of the rice factors the better the system performance, and this means that means L.O.S components dominate the other components. Moreover it is concluded that the system performance is more degraded due to the partial jamming effect.

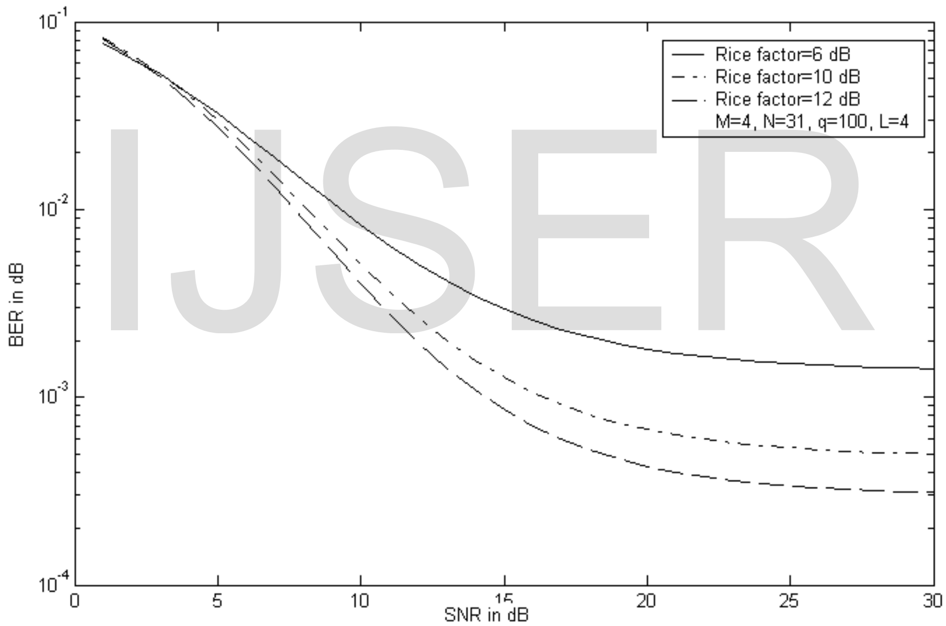

Figure 2 BER of hybrid DS/SFH over Rician fading channel

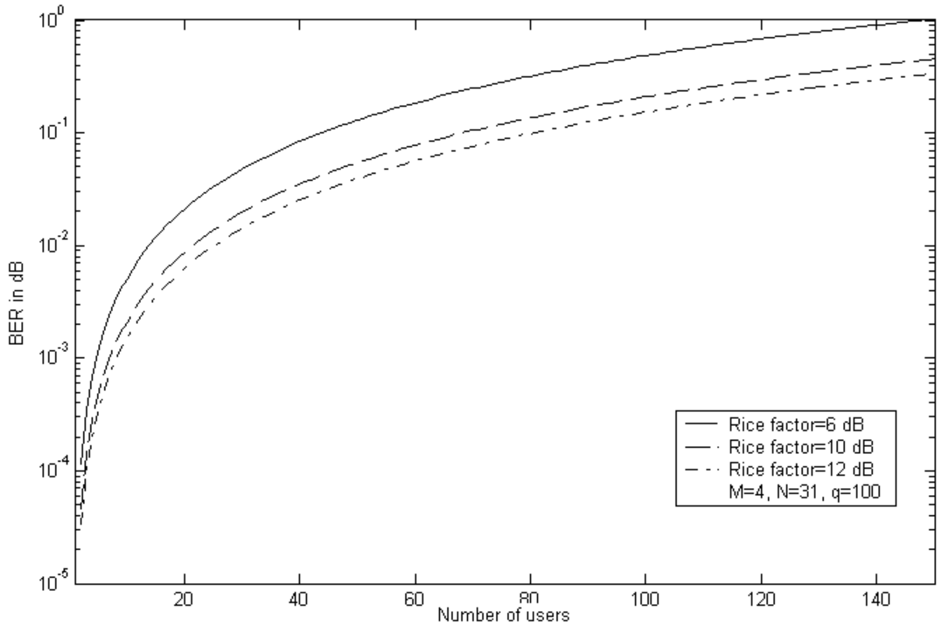

Figure 3 Capacity of hybrid DS/SFH over Rician fading channel

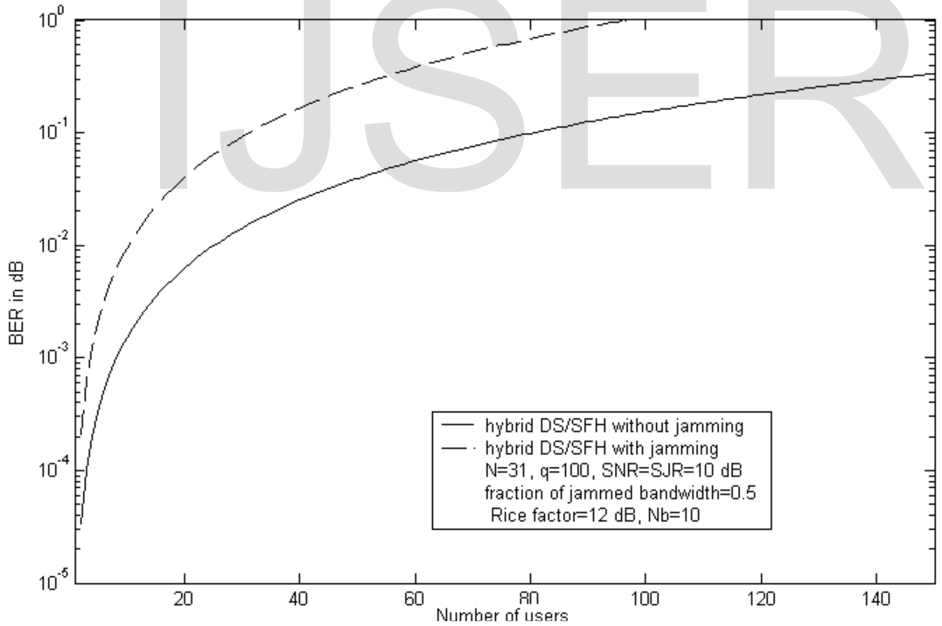

Figure.4 Comparisons between system capacity of the hybrid DS/SFH over Rician fading channel with PBJ and without PBJ

ISSN 2229-5518

6. REFERENCES

1. Lie- liang Yang, Hanzo L. "performance of generalized multicarrier DS-CDMA over nakagami-m fading channel ", IEEE Trans. On communication Vol. 50, No. 6 June 2002.
2. Marvin K-Simon, Jim K-Omura, Robert A Scholtz and Barry K. Levitt, " Spread spectrum communications handbook," McGraw Hill Inc., 1994.
3. Usa Svasti Xuto, Qiang Wang and Vijay K. Bhargava "Capacity of an FH-SSMA system in different fading environments ", IEEE Trans. On Vehicular Technology Vol. VT-47, No. 1 February 1998.
4. Kah C. The, and Kwok H. Li, "Error Probabilities of an FFH/BFSK self normalizing receiver in a Rician fading channel with multitone jamming", IEEE Trans. On Comm., Vol 48, No. 2 February 2000.
5. John G. Proakis "Digital communication", McGraw Hill , 2000.
6. Wong Sub Kim, Kenue Yeol Jeong, and Kyung Sik Kang “Performance analysis of the FH/CPFSK system under partial band jamming”,ICCS 2002
7. Zhenhui Tan “Bounds on performance of RS coded hybrid DS-SFH SSMA for indoor wireless communication” IEEE vehicular technology 1993